An alternative approach to plant health: The procedural concept applied to common bean seed systems

STEPHANIE M. KLAEDTKE[12], PIERRE M. STASSART[2], VERONIQUE CHABLE[1]

Key words: plant health, common bean, *Phaseolus*, organic seed production, crop biodiversity

Abstract

The pathogenic bacteria causing Common Bean Blight (CBB) is regulated as quarantine pest on bean seeds in the European Union. While they may reduce damage to crops and delay the global spread of pathogens, such phytosanitary regulations can represent a market barrier to small scale organic seed producers. Under the hypothesis that different conceptions of plant health are confronted in debates on CBB and seed quality, a procedural concept for the definition of plant health is applied to the case of small-scale organic bean seed production. Questions within the thematic areas of (i) the socio-technical networks, (ii) pathosystem and biology, (iii) epidemiology, (iv) crop environment and (v) anthropocentric aspects are treated in the framework of an ongoing research project to obtain a situated, contextualized understanding of plant health and management strategies.

Introduction

Common bean (*Phaseolus vulgaris*) constitutes a valuable source of protein in human diets worldwide. While its production remains high in many African and Latin American countries, it has decreased in Western Europe. Seed production follows the same trend: While common bean seed production decreased from 10.760 to 2.230 tons between 1962 and 2012 in Western Europe, it has increased from 51.160 to 249.710 tons in Eastern Africa (FAOSTAT). However, some small scale, mainly organic, artisan seed producers produce and market common bean seed in Western Europe, often seeds of traditional varieties for gardeners and vegetable producers selling to local markets. Several seed-borne pathogens, including fungi, viruses and bacteria, represent one of the challenges to the production of this seed. *Xanthomonas axonopodis* var. *phaseoli* (Xap), causing Common Bean Blight, is regulated as quarantine pest on seeds in the European Union (EU 2000). Such phytosanitary regulations can represent a market barrier to small scale organic seed producers, as contaminated seed lots are banned from commercialization, potentially causing serious economic damage. In addition, such regulations may threaten agro-biodiversity. In the case of Xap, pathogen-free seed lots are no longer available for some traditional common bean varieties, making their multiplication difficult as curative measures are not available.

We emit the hypothesis that different conceptions of plant health are confronted in debates concerning Xap as a quarantine pest. In what might be termed as a *hybrid forum*, stakeholders are unable to find common definitions of the problem, let alone identify its causalities or measure its effects (Callon, 1999). Rather than defining plant health as an objective entity, Döring *et al.* (2011) propose a procedural concept consisting of a set of topics and rules for debate in order to incorporate different viewpoints on the continua between naturalist and normativist approaches, negative and positive definitions, reductionism and holism and functionality and resilience. After a brief overview of the set questions for debate suggested, they are applied to the case of common bean seed produced by small-scale organic seed producers in Western Europe as treated by an ongoing research project.

The debate procedure applied to common bean seed production

The procedural concept proposed by Döring *et al.* for the definition of plant health consists of a set of questions grouped according to five topics. These can be summarized as [i] the socio-technical network (the perception of the pathosystem by the people involved), [ii] pathosystem and biology (co-evolution of plant and pathogen, effect of pathogenic organism on the plant's vital functions), [iii] epidemiology (development and effect of the disease in individual plants and populations, response of affected plants to stress conditions and pathogenic organisms), [iv] crop environment (the role of the environment and management) and [v] anthropocentric aspects (genetic potential of plants; affects of pathogen on yield, quality, ecosystem functions, human health and welfare and socioeconomic functions). While the first three topics may be

[1] INRA SAD, 65 rue de St. Brieuc, CS 84215, 35042, Rennes, France, eMail : stephanie.klaedtke@rennes-inra.fr.
[2] Socio-Economy Environment and Development, Liège University, Av. Longwy 185, 6700 Arlon, Belgium

tackled with disciplinary knowledge within social or natural sciences, the other two call for interdisciplinary approaches and the involvement of practitioners and other stakeholders in the debate.

Research was started in 2012 in the framework of the FP7 project SOLIBAM to study seed health in the context of small-scale bean seed production from several perspectives and disciplines. The topics for debate on plant health are approached as follows.

Considerations on the socio-technical network

Questions referring to the socio-technical network seem very relevant in the case studied here, as the very research subject resulted from small-scale seed producers' observation that phytosanitary regulations do not match practical experience and feasibility in bean seed production. Debates on Xap and plant health involving seed producers, seed testing institutions, researchers and other stakeholders lead to the hypothesis that different conceptions on plant health exist. On one hand, the ideal of pathogen-free seed, leading to the regulation of pathogens as quarantine pests in extreme cases, is one strategy to "protect plants" and prevent "the introduction and spread of dangerous pests" (EPPO website). While this strategy reduces damage to crops and delays the global spread of pathogens, it may on the other hand be regarded as an overly reductionist approach to plant health disfavoring the resilience of cropping systems (Demeulenaer 2013). A more normativist approach based on a positive concept of plant health may be more suited for organic, small scale seed production. Indeed, ecological plant protection relies on interactions in the ecosystem to provide regulation of pathogens and pests. It is more likely to embrace a salutogenic position "focusing on more complex interactions between plants and pathogens, such as induced resistance phenomena" in order to "move towards health" (Döring *et al.*, 2011). To validate calls for a more complex and holistic understanding of phytosanitary issues, a qualitative survey will be realized with bean seed producers, researchers and other stakeholders. Comprehensive interviews will include topics such as criteria for seed quality, seed and crop management strategies and forms of social organization.

Pathosystem and biology

A set of questions concerning the effect of pathogens on plant functions and the development of pathogens under certain pedoclimatic conditions can be answered by reviewing literature on relevant plant diseases. As a model crop of global importance, a lot of research has concentrated on common bean pathogens, leading to a wide range of scientific literature and text books (reviewed by Broughton *et al*., 2003; Singh and Schwartz, 2010). Research conducted under laboratory, green house or experimental station conditions produces knowledge that is out of context, but which nevertheless provides elements to better understand the pathosystem we are dealing with. Knowledge on possible biological interactions between Xap and its host and on the damage potential of the pathogen helps to explain and situate field observations.

Epidemiological aspects

Another set of questions refers to the effect, severity and spread of plant diseases. Whereas general information on the prevalence of Xap in certain regions of the world can be found in literature, the epidemiological development of the pathogenic bacteria is strongly dependent on environmental conditions and famer practices. For instance, inoculum thresholds of seedborne bacteria leading to epidemic development are likely to depend on plant-pathogen-environment interactions (Darrasse 2007). These aspects are therefore tackled by on-farm field trials with the varieties of implicated producers. Field trials with 4 traditional bean varieties and one commercial check were set up on three farms with contrasting pedoclimatic conditions in France and Luxembourg in 2012. For the following three years, bean seed will be multiplied and resown on every site under field conditions. Notations on disease symptoms, counts on the number of surviving plants, grain yields and seed testing for pathogenic microorganisms will allow assessing the development of seed-borne diseases in the plant populations and in time. As these trials are conducted under the conditions of small-scale organic production and with involved farmers' seed lots, the link to the fourth topic for discussion is obvious.

The role of the crop environment

When faced with large genotype*environment interactions, the exploitation of specific plant adaptation and the use of different methodologies and types of germplasm in decentralized crop breeding are recommended strategies for yield maximization (Ceccarelli 1996) or yield stability. In the field trials, the specific adaptation of seed lots to their environment is studied, as well as the interactions between plants, pathogens and other microorganisms. A large number of soil microorganisms have been shown to interact with plants and to improve plant vigor and induce resistance not only to soil-borne pathogens, but also to foliar and systemic plant pathogens. Among them, arbuscular mycorrhizal fungi (AMF) and *Rhizobium* sp. play a predominant role for legume crops (Avis *et al.*, 2008). They may thus be considered as important factors in an alternative approach to plant health and crop resilience. However, the majority of research on the effect of these microorganisms on plant health has been conducted under laboratory or green house conditions, making it difficult to assess their role in real-life cropping systems. Assessing the symbiosis of bean plants with these microorganisms in farmers' fields thus allows (i) getting a broad view of the interactions between bean crops and soil microorganisms and the effect on plant health on-farm and (ii) drawing first conclusions on the perspectives of alternative plant protection strategies based on interactions with locally present endogenous microorganisms and induced resistance.

However, the question on the role of farmers' management practices goes beyond the mere description of practices and validation of the role of soil biology for plant health and resilience under field conditions. Farmers' understanding of their production systems influences the management strategies put in place. For instance, small-scale artisan producers combine the objectives of producing seed, managing crop biodiversity and maintaining the know-how and practices around seed production within their communities. Working with local networks and artisan techniques entails very different management strategies than the large scale seed production on a global market. A holistic approach to research which does not consider research results without their context calls for the participation of and active interaction between stakeholders (researchers included) in a research process that is not defined beforehand.

The anthropocentric view on plant health

A final set of questions aiming at the effect of Xap on grain yields, ecosystem functions of the crop and, finally, human health and welfare appears to be straight forward and measurable at a first glance, but actually leads to a discussion on human goals and values in seed and food systems: Measuring the effect of Xap on grain yields requires measuring the genetic potential of the bean crop. However, small-scale seed producers choosing to produce traditional bean varieties organically are seldom interested in the genetic yield potential of their bean variety under optimal conditions, but rather in the adaptation to their local crop environment. Or as one French farmer puts it: "We do not merely sow genes in our fields. We sow live seeds which are accompanied by a large diversity of microorganisms." Beyond grain yields and measurable product quality, the role of local agricultural systems from seed to soup in defining food quality and the importance of agro-biodiversity as an ecosystem function are only two topics that need to be discussed for individual communities. Pathogens may even be regarded as part of the production environment. Maintaining interacting networks of coevolving populations would thus enable hosts to respond better to future disease threats, as has been argued in the case of natural systems (Altizer *et al.* 2003).

Perspectives and challenges

By involving practitioners and other stakeholders in a debate procedure including different, possibly contradictory views and allowing for hesitation (Stengers 2006) on practices concerning plant health, the project described is one example of bridging the gap between scientific knowledge and practice. Such procedural approaches to research allow reconnecting academia, which has become ever more specialized in disciplines, with reality in the field. To result in social learning processes and develop relevant new forms of knowledge and networks, the rules for debating are as important as the topics themselves. A fair and equal debating process between appropriate discussion partners, a sufficient time frame for assessments and decisions and transparency are among the rules to be respected. These rules also represent important challenges for researchers. It is important to be aware that results of this form of research are situated and contextualized, and not universal as scientific results have long been regarded. How such results can be applied to seed production systems under present conditions, particularly regarding the regulatory framework of seed production, remains to be seen. Perhaps a procedural take on policy development would be one logical consequence for seed regulations?

Acknowledements

SOLIBAM (Strategies for Organic and Low input Integrated Breeding and Management - 2010-2014) is funded by the European Community's Seventh Framework Programme (FP7/2007–2013) under the grant agreement n. 245058. The PhD research is supported by the Fonds National de la Recherche, Luxembourg (project 5126594).

References

Altizer S, Harvell D & Friedle E (2003): Rapid evolutionary dynamics and disease threats to biodiversity. Trends in Ecology & Evolution 18, 589–596.

Avis TJ, Gravel V, Antoun H & Tweddell RJ (2008): Multifaceted beneficial effects of rhizosphere microorganisms on plant health and productivity. Soil Biology and Biochemistry 40, 1733–1740.

Broughton WJ, Hernández G, Blair M, Beebe S, Gepts P, & Vanderleyden J (2003): Beans (*Phaseolus* spp.) – model food legumes. Plant and Soil 252, 55–128.

Callon M (1999) : La sociologie peut-elle enrichir l'analyse économique des externalités? Essai sur la notion de cadrage-débordement. In: Foray D & Mairesse J (eds): Innovations et Performances: Approches Interdisciplinaires, Recherches D'histoire et de Sciences Sociales. Editions de l'Ecole des hautes études en sciences sociales, Paris, 399-431.

Darrasse A, Bureau C, Samson R, Morris CE & Jacques M-A (2007): Contamination of bean seeds by *Xanthomonas axonopodis* pv. *phaseoli* associated with low bacterial densities in the phyllosphere under field and greenhouse conditions. European Journal of Plant Pathology 119, 203–215.

Döring T F, Pautasso M, Finckh MR & Wolfe MS (2012): Concepts of plant health - reviewing and challenging the foundations of plant protection: Concepts of plant health. Plant Pathology 61, 1–15.

Demeulenaer É (2013): Les semences entre critique et expérience : les ressorts pratiques d'une contestation paysanne. Revue d'Etudes en Agriculture et Environnement, 94(4) : 421-441.

EPPO (2013): Data Sheets on Quarantine Pests: *Xanthomonas axonopodis* pv. *phaseoli*, prepared by CABI and EPPO for the EU under Contract 90/399003. http://www.eppo.int/QUARANTINE/bacteria/Xanthomonas_phaseoli/XANTPH_ds.pdf (accessed on the September 29th 2013 at 20h52).

EU (2000): Council Directive 2000/29/EC on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community, 63.

Singh SP & Schwartz HF (2010): Breeding Common Bean for Resistance to Diseases: A Review. Crop Science 50, 2199-2223.

Stengers I (2006) : La vierge et le neutrino, des scientifiques dans la tourmente. Paris, Les empêcheurs de penser en rond.